

What is claimed is:

1. A failure detection apparatus for an internal combustion engine, comprising:

5       fresh air quantity detecting means arranged in an intake system of the engine, for detecting a quantity of fresh air introduced into a combustion chamber of the engine;

10      fresh air quantity reference value setting means for setting a reference value for the fresh air quantity in accordance with an operating state of the engine;

15      failure detecting means for detecting abnormality of said fresh air quantity detecting means, based on a result of comparison between the fresh air quantity detected by said fresh air quantity detecting means and the reference value set by said fresh air quantity reference value setting means;

20      an EGR passage for allowing part of exhaust gas to be recirculated from an exhaust system of the engine to the intake system as EGR gas;

25      an EGR valve inserted in said EGR passage, for controlling a quantity of the EGR gas by varying an opening thereof;

target opening setting means for setting a target opening for said EGR valve in accordance with the operating state of the engine such that an air-fuel ratio or excess air ratio of the exhaust system becomes equal to a predetermined value corresponding to the operating state; and

30      EGR valve control means for controlling said EGR valve in accordance with the target EGR valve opening set by said target opening setting means,

wherein said fresh air quantity reference value

setting means sets the reference value in accordance with not only the operating state of the engine but also the target EGR valve opening set by said target opening setting means.

5       2. The failure detection apparatus according to claim 1, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

10      wherein said fresh air quantity reference value setting means corrects the target EGR valve opening based on a difference between the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, and the predetermined value, 15 and sets the reference value based on the corrected target EGR valve opening.

20      3. The failure detection apparatus according to claim 1, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

25      wherein said EGR valve control means corrects the opening of said EGR valve such that the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust concentration detecting means, coincides with the predetermined value.

30      4. The failure detection apparatus according to claim 1, further comprising exhaust concentration detecting means for detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

      wherein, when the air-fuel ratio or excess air ratio of the exhaust system, detected by said exhaust

concentration detecting means, is different from the predetermined value, said fresh air quantity reference value setting means suspends the control of said EGR valve by said EGR valve control means and sets the reference 5 value based solely on the operating state of the engine.

5. A failure detection method for an internal combustion engine including an EGR passage for allowing part of exhaust gas to be recirculated from an exhaust system of the engine to an intake system of same as EGR gas, 10 and an EGR valve inserted in the EGR passage for controlling a quantity of the EGR gas by varying an opening thereof, said failure detection method comprising the steps of:

(a) detecting a quantity of fresh air introduced into 15 a combustion chamber of the engine;

(b) setting a target opening for the EGR valve in accordance with an operating state of the engine such that an air-fuel ratio or excess air ratio of the exhaust system becomes equal to a predetermined value corresponding to the 20 operating state;

(c) controlling the EGR valve in accordance with the target EGR valve opening set in said step (b);

(d) setting a reference value for the fresh air quantity in accordance with the operating state of the 25 engine and the target EGR valve opening set in said step (b); and

(e) detecting abnormality in the detection in said step (a), based on a result of comparison between the fresh air quantity detected in said step (a) and the reference 30 value set in said step (d).

6. The failure detection method according to claim 5, further comprising the step of (f) detecting an exhaust concentration to thereby detect the air-fuel ratio or

excess air ratio of the exhaust system,

wherein in said step (d), the target EGR valve opening is corrected based on a difference between the air-fuel ratio or excess air ratio of the exhaust system, detected in said step (f), and the predetermined value, and the reference value is set based on the corrected target EGR valve opening.

7. The failure detection method according to claim 5, further comprising the step of (f) detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

wherein in said step (c), the opening of the EGR valve is corrected such that the air-fuel ratio or excess air ratio of the exhaust system, detected in said step (f), coincides with the predetermined value.

8. The failure detection method according to claim 5, further comprising the step of (f) detecting an exhaust concentration to thereby detect the air-fuel ratio or excess air ratio of the exhaust system,

wherein, if the air-fuel ratio or excess air ratio of the exhaust system, detected in said step (f), is different from the predetermined value, the control of the EGR valve in said step (c) is suspended and the reference value is set based solely on the operating state of the engine in said step (d).